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THE REMARKS ON THE STRATEGY OF THE DIGITAL GRAVITY DATABASES BUILDING IN UKRAINE

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The **purpose** of the research note is to design gravity surveys database conditions due to its improved precision and to the advanced software for the processing and interpretation of gravity data. The note formulates adequate requirements to the modern geophysical practice by the optimal precision for the interpretation means of the potential fields' data. Main trends of reinterpretation of data being stored in the archives are pointed out to create a unified digital framework for the geophysical databases. We denote that the main problems on this way there are the creation of high-speed solutions for digitization of maps and the creation of digital databases on modern OS platforms.

In unique **approach** a series of separate branches are generalized, justifying the creation of a new methodology for gravity (and other) databases for the territory of Ukraine. In particular, we suggest the follow series of **findings**:

- As a database engine, one should use a PostgreSQL db management system;
- As a method of paper maps digitizing one should use the modified A. Yakimchik technique (where an input for digitizing is not the *contour maps*, but the *measurements log* (map of the observation points converted into the digital grid map of gravity anomalies); the technique is updated by the open-source analogues of given proprietary software;
- As a new standard of preprocessing of gravity data one should to use the adapted technique of S. Bychkov for counting the layer curvature, relief contribution and indirect effects; one should develop its own parameters for calculating of gravity corrections for the spherical layer impact and other effects on the territory of Ukraine).

Drawing **implications**, we also recommend adding the maps of the absolute values of the gravity field to the standard set of maps for the interpretation. For this reason, we suggest to change the Instructions on gravity surveys of 1980. To ensure the database universality one should combine in a united interface of thematic portal with the public access not only the gravity data but also the complementary data on the area of research. The proper way to do all the strategy of gravity databases building is to change not the secrecy bar on gravity data, but the concept of intellectual property itself: to replace competition within the access to measurements data by the competition on the results of data interpretation.

Key words: gravimetry, databases, maps digitizing, reinterpretation of archive data, catalogue of gravity stations, absolute values of gravity, new standard.

Introduction

Beyond almost two decades of decline, due to sharp reduction of the volume of field surveys and to development of mobile methods of near-surface geophysics, gravity exploration experiences the certain getting up again. The rise is caused by the reorientation of a geological survey orders from government services to the private sectors of geophysics, because of new public relations assigned. Private companies produce enhanced requirements to methodology optimal by the expenses (for *minimum* of time it is required to execute a *maximum* of surveys of *acceptable quality*) and to the accuracy (resolution) of *measuring*. A modern foreign apparatus and methodologies of measuring, tested by time, are adequate to the modern requirements to the data acquisition. But we need an compatible data background basis for these new machinery.

The same requirements by the optimality and exactness, however, they produce also to facilities of *interpretation* of the potential field data in the modern geophysical practice. The **purpose of this note** is to design some adequate modes for the data acquisition and storage. Particularly, they are such conditions:

1. A high *accuracy*, technologibility (expansibility, compatibility of formats) and mobility (operation in different configurations of "hard" and software) of the algorithms and programs;

2. An adaptation of the mathematical models of the field to realities of measuring: the acquirement of the initial measuring on the short profiles or in the irregular framework of supervisions;

3. An adaptation of the mathematical models of geological media to the realities of its structure, i.e. to the complicated (nonlinear and heterogeneous) state of structures, to the dispersion of its physical properties.

There are enormous volumes of gravity measuring of acceptable quality in the archives, acquired within the second half of XX century. Because of these, much attention is spared to the questions of its *reinterpretation* upon the new basis. However, because of advanced requirements to exactness and efficiency of the interpretation, the reprocessing of large bulk of gravity data requires follow actions to be performed:

1. The incorporation of a new *numeral methods* and models [3-6] for interpretation of gravimetry data;

2. The introduction of a new base of gravimetry and the *change* of the existent *standards* of gravity measurements preprocessing [1, 13];

3. The use of a new technique of preparation of the digital maps and databases [11, 12];

4. The implementation of a new presentation of the initial gravity data [8].

All of the indicated directions of enhancement of methods of processing of the potential fields data are on the different degree of advance. All of them develop with a breech-sight on the creation of digital analytical models of the gravity field and geological media, being oriented to the application within the GIS pac-

kages (a visual model of interactive interpretation). To provide a unique digital basis for the geophysical databases, one need to convert the paper maps being kept in archives in the different reductions into a digital form, while taking into account the four conditions indicated higher. Because of the findings stated above, there the problems of how to create of speedy and inexpensive solutions for digitizing of cartographic heritage of previous epoch of the geophysics advance and how to create the digital databases on modern programming platforms are still of great actuality. Analysis of the problems constitutes an essence of **approach**.

Besides, some thinking stereotypes in geophysics impede the general advance in Earth sciences. The information flood demands knowledge ranking and techniques generalization. Such interaction is possible based on interactive portals, which integrate the theoretical approaches, numerical algorithms and databases. The main content of these portals must be digital maps packages of potential fields. But the known geotracing programs (as Surfer, Easy Trace, ErMapper, MapInfo, ArcGIS, CorelDraw) have a very hard and slow digitizing modes, incompatible data formats, poor analysis facilities, intricate interface, multistage procedures, inconsistence with big data arrays etc. So, extensive development of digital cartography (the more performance – the more data) we suggest to replace by intensive one (the more data – the more capacity).

A generalization and preprocessing of the primary data

We offer the series of the generalizations, validating a requirement in the development of new methodology for the creation of multicomponent databases of geologic and geophysical information (mostly the potential field data) for the territory of Ukraine. Further, there one keeps in mind the gravity data, as most close to the author of report. Therefore, **our findings** are as follows.

1. As a kernel of database, it is fully possible to use the PostgreSQL, according to an analysis [2]. Indeed, the geological databases now are not limited by the storage and access to the data of researches. However, the unique approach to development of such databases is not developed yet. The comparative analysis of Database Management System trends for maintenance of large arrays of spatial data was made. The research, while keeping in mind the visualization and processing of data, reveal us that the most convenient and stable software for GIS map building and spatial data binding are the Oracle and PostgreSQL. Preference was given to the last one as open-source analogue.

Among the advantages of the PostgreSQL there are reliability and security of data (DB access is verified by the corporative authentication engine, as LDAP or Kerberos, data exchange by SSL commutation). For geographic (geological) data treatment there are PostgreSQL extension Postgis, which deals with the GIS objects. PostGIS creates SQL queries with the spatial functions, supports bitmaps and GiST indexes. The GiST indexes are preferable before R – Tree ones because of null safe data treatment and lossiness support (more 8K GIS index calls preserve only significant part of object information). The OpenGIS specification supports two ways for spatial objects exchange – Well-Known Text (WKT) and Well-Known Binary (WKB), which you may easily transfer into the Quantum GIS environment.

2. As a digitizing of paper maps procedure, we use a technology [11], which uses as initial information prior to the beginning of digitizing not the ordinary *maps of isolines*, but a new type of digital information in kind of electronic logs of measuring. This technique transform not the paper map of isolines into the same digital map of isolines, with all its errors and problems, but the *map of data records* (fig. 1a) – into the digital grid-map of anomalies, ready to processing within the environment of the specialized scientific packages.

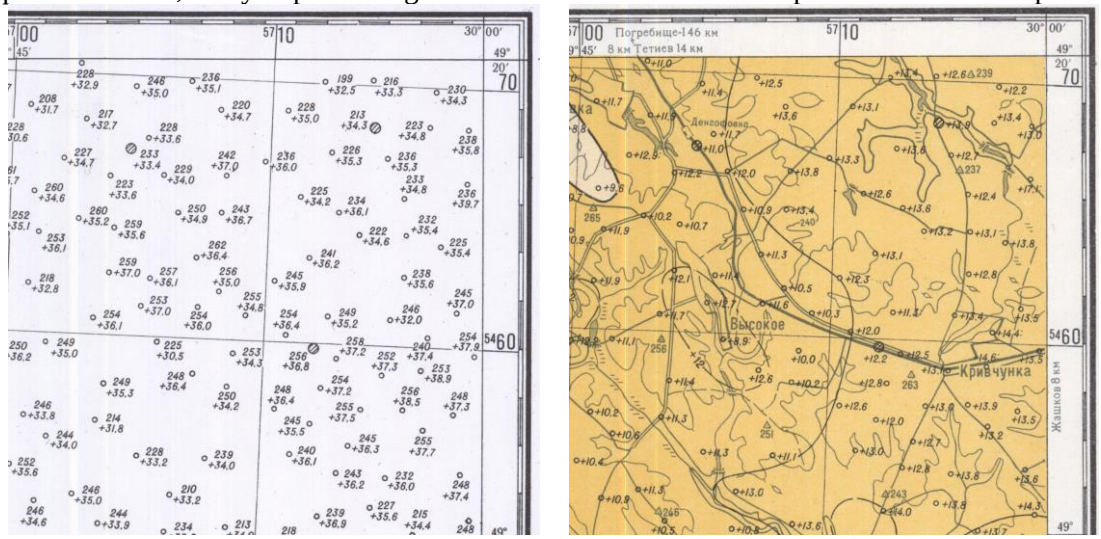

Fig. 1a. *Fragment of gravimetric map of USSR, sheet M-35-XXX of scale of 1:200 000: on the left are heights of measured points, on the right are a Bouguer gravity anomalies (σ = 2.3 g/cm^3).*

Amendment is introduced only on the fact, that since a publication [11], because of progress of GIS techniques, it is recommended to replace used there proprietary programs by the open-source ones [7, 12]. In addition, the same tendency to the open-source foundation of the processing facilities it is necessary to pawn into a strategy of further development of database projects.

It is worth to submit some key regulations of the digital maps creation, described in the paper [11] for more detailed consideration. Therefore, as stated in the paper [11], the known input procedures for map images by means of digitizer and scanner to convert the scientific curvilinear data types into a digital kind are hard and time-taking. Thus, the program of introduction of maps from a scanner [10] executes 10 operations: introduction and coding of image → smoothing of contours → noise removal → skeleton extraction → piecewise-linear approximation → tracing of segments of isolines → digitizing of values of isolines → record of results.

For treatment and interpretation of geophysical information from maps of actual material it is required the automation of their input into the computer. While GIS developed, they give possibility to perfect procedure above, for example, in this way (treatment of the relief images): scanning of map → record in the file → loading into the Golden Software Surfer → digitizing of map → record of heights into the data file (x and y automatically, height z by hand) → export of file. Lacks of the method described:

1. digitizing of horizontals diminishes the precision and authenticity of points coordinates of and field values in these points;

2. Surfer 11 prolongs duration of digitizing, while gives the ambiguous results: (different operators still generate different results, based on different interpolation methods);

3. Labor intensiveness and inconvenience of digitizing greatly hardens all the procedure.

There were designed a new method of digitizing of the scanned maps of actual material within GIS MapInfo Pro in order to provide automation, authenticity, precision and minimal time of input of graphics into a computer within the framework of geodesic/rectangular coordinates. We use as data inputs the scanned maps of factual material (gravimetrical points map), which contain the grid of observations points and the values of anomalies on these points (fig. 1b), where denoted are: red circles – observation points; fractions – values of anomaly/height; dashed lines – an isolines, got from interpolation on a plane; [i] – operation panel for isolines processing.

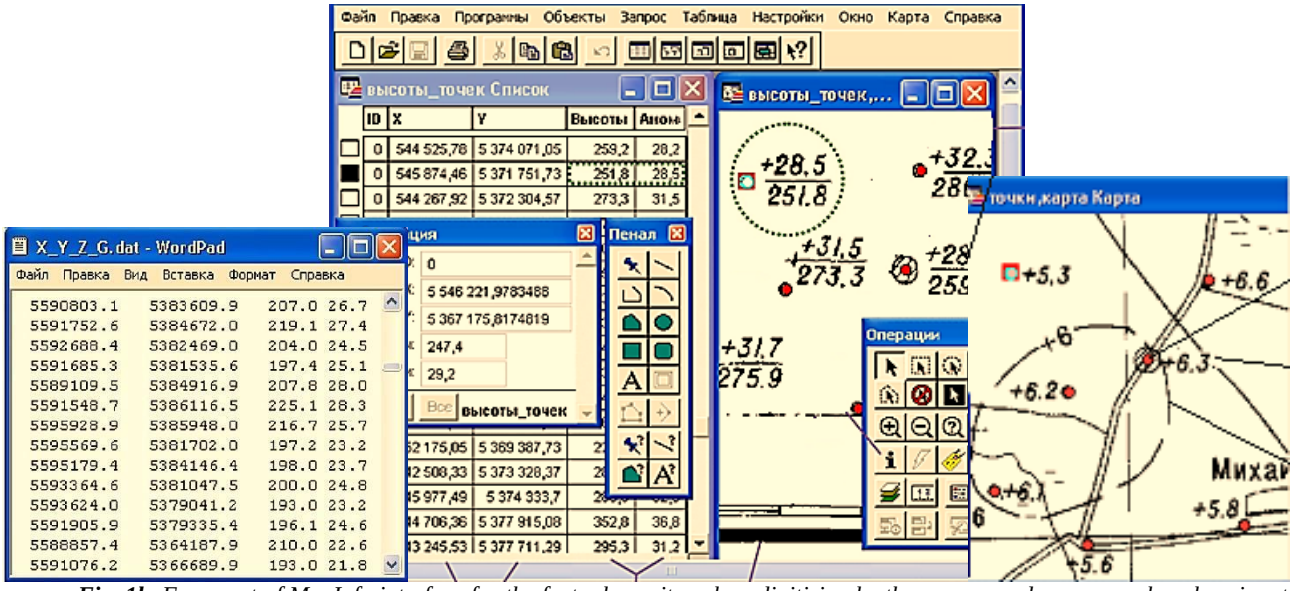

Fig. 1b. *Fragment of MapInfo interface for the factual gravity values digitizing by the new procedure: anomaly values input during digitizing grid-map of observations.*

Before the main procedure starting, we calibrate the map sheet by the corners of internal scope: in the program Photomod GeoCalc 4.2, we transform the *geodetic* coordinates of map corners of trapezoid scope into the *rectangular* coordinates of map sheet. The coordinates of these supporting points help us to define automatically coordinates of all other points. Essence of the matter lies in consecutive implementation of next 4 stages [11].

a) **A registration of the raster**. In order to confront a raster with vector data above it, we register a raster image: within a "Registration of image" window of MapInfo, we set the coordinates of reference points, projection type of raster: *File → Open table → File types → Raster* and file of raster → *Open → Register* → "Registration of image": set the projection of map scan, fix the 4 corners of internal scope, within "Add a control point" window set its *rectangular coordinates → Save Worksheet.* In upper part of "Registration of

image" window, you will see the coordinates of 4 reference points mentioned.

b) **Vectorization**. A computer map is an aggregate of layers, which contains the different types of information: areas, points, lines texts etc. For a layers management one should use the panel *Operation → Layers management*. For the digitizing of point objects they are inflicted on a *cosmetic layer* of map: to open a worksheet, you should set the mode *Nodes*, set *Map → Layers management →* choose cosmetic layer from a list, to flag *Variable*, to choose *Symbol style →* set symbols, fonts, color, size of all point objects on a cosmetic layer. Then choose a drawing instrument *Symbol*, point out the cursor into place of map, where a point object is inflated, fix it with the left mouse button on a background a raster image. After applying all of the points, you should save vector objects in an existent/new table: *Map → Save cosmetic.* Then run the MapBasic, and go to the "Write coordinates of object" tab; the program automatically fills two columns of table by the coordinate values in the given projection. After that, you should rebuild the structure of the table calculated.

c) **Input of anomaly values**. We set the numerical values for every point of the map layer. To do this, we open a table as map and a list, and dispose the windows alongside. Then we highlight an object within a right window, and within a left one input the value of anomaly. Thus, we repeat so for all of other points and to save a table: *File → Save file table.* Here a point object is highlighted simultaneously on the left and on the right window, whatever no one point is skipped out.

d) **Export to ASCII.** To export tabular data in MapInfo in ASCII files, choose a symbol-delimiter in the window "ASCII-text" and go. Then you may to revise a file obtained and to load it into the interpretation of the geophysical fields' framework, as Geosoft Oasis Montaj.

The method described provides the precision and great efficiency of geophysical maps digitizing; the maximal automation, authenticity, simplicity and comfort of input of cartographic data in a computer within GIS environment; an acceleration of decision rates for the applied problem solutions in the Earth sciences.

Substantial issue of that technique is the possibility to use different software facilities for the maps calibration, including the own developments, if they support the batch data processing. In addition, from 4 basic procedures described the vectorization and export of data can be automated, and the rest get such possibility in the future, while spreading the convenient programs of patterns recognition and geophysical data banks.

Our suggestion to the technique described in section 2 is as follows. Whereas at the maps digitizing the large functional of proprietary MapInfo is not involved, then you should involve open-source GIS Quantum GIS Wroclaw 1.7.4 instead, and vice of proprietary Photomod GeoCalc 4.2 you should use an applet of "Package coordinate converter" from open-source package OkMap [7].

3. As new standards of reducing and primary processing of gravity data because of growing exactness and details of the investigations taking into account corrections for curvature of layer, hypsography and indirect effects, it is necessary to accept the point of view of Bychkov S. et al. [1]. They advise to correct the gravity data for indirect effects, for atmosphere impact, for the spherical layer (new Bouguer corrections).

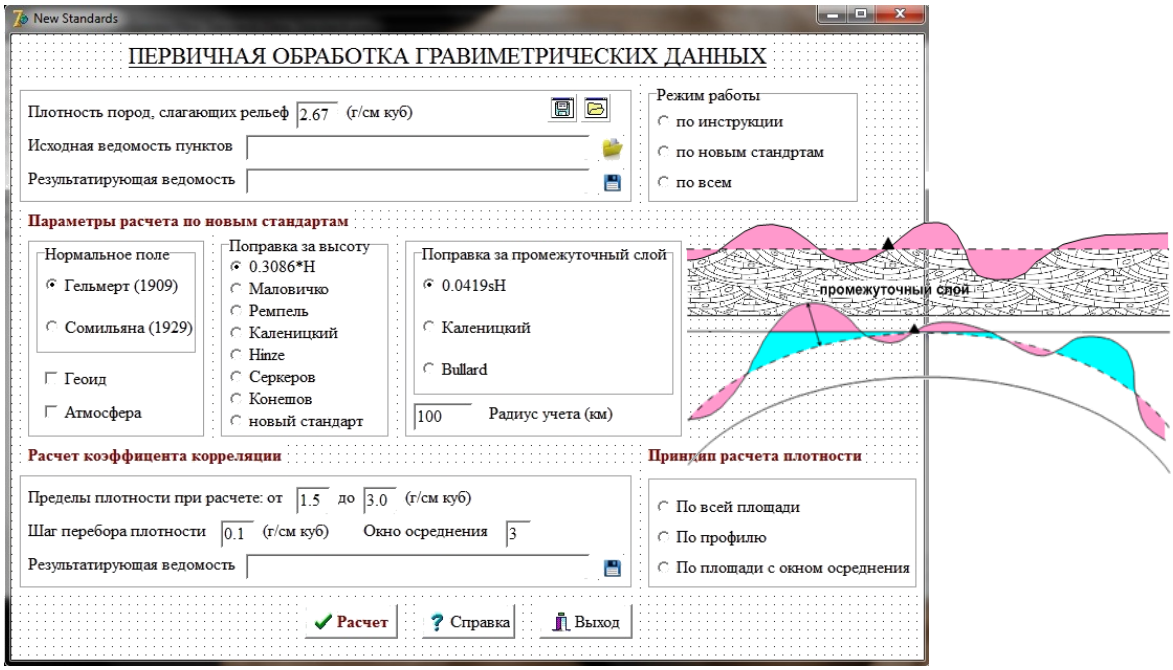

Fig. 2. *Interface of the program New Standards [1] for preprocessing of the gravity measuring's and its substantiation.*

So, one need to remove thinking stereotypes in the calculations of anomalies of gravity at the creation of appropriate digital databases. It is thus necessary at once to develop for the basic structural areas of the territory of Ukraine the own parameters of calculation of gravity corrections by the new standards (geodetic datum PZ-90), taking into account existent findings (fig. 2), and to change properly Instruction on gravity exploration of 1980.

The reprocessing of gravity corrections for the geological conditions of the Ukraine are still under development. Thus, the problem of new standards for gravity corrections is well grounded, but its numerical values for main tectonic zones of Ukraine need further revisions.

An input gravity data and its new presentation

4. Next generalization, also requiring the change of positions of Instruction on gravity exploration of 1980, is contained in a report [8]. Here is proved the use of map of absolute values of the gravity field g_{obs} of scale of 1:1000 000, created for the territory of Ukraine by efforts of a number of Ukrainian institutes. The creation itself of this map on the base of reliable elevation digital basis of daily surface (created in the Institute for the geodesy and cartography as tables of heights values in the Baltic frame of reference) brightly testifies in behalf of creation of unique data center in internet. Having similar basis, the map of absolute values of g_{obs} and a number of it transforms (fig. 3) is created by a count on the Helmert formula within a regular matrix. It is recovered by the data of summary map of Bouguer anomalies (σ = 2.3. g/cm^3) of scale of 1:200 000. The last one is presented from the complete set of maps of the Geophysical basis for the Tectonic map of Ukraine of scale of 1:1000 000. Now, to get the specified map, or maps of the field transforms, it is enough to change the formula of count or parameters of ellipsoid (datum) within the interface of database.

Nowadays the prices reduction of devices and increase of its calculus power, development of new GIS allow us to apply GIS in gravity processing. For the analysis of the spatial geophysical features, there are necessary arrays of gravity surveys data. The maps of 1:200000 scale with the section of isoanomals of 1-2 mGal covers 100% territory of Ukraine, the ones of 1:50000 scale with the section of isoanomals of 0.5 mGal – 38% territory, the ones of scale of 1:50000 and larger with the section of 0.1÷0,25 mGal covers 31% territory. The total area of gravimetric survey is of ~603700 км^2, which comprises of ~14,5 million the observations points. In geological funds, the lots and many gravimetrical materials of different time are accumulated on a paper. Their effective use is feasibly by means of GIS environment and creation of data banks. The databases we recommend to create based on the above-mentioned digitizing method for data, presented as a map of factual material, with the Quantum GIS. While gravity logs now are still inaccessible, we concentrated on the digitizing of the piece of data, stored in the author's institution.

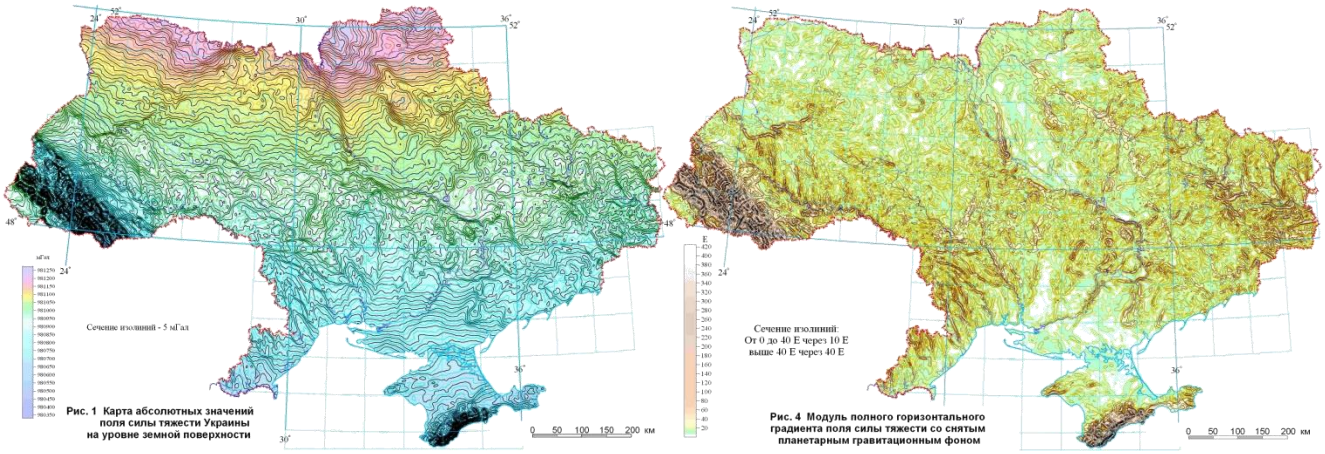

Fig. 3. *Maps of absolute values of gravity (on the left) and its module of complete horizontal gradient (on the right) with the planetary background subtracted [10].*

5. The next generalization step touches the concept of universality of databases: data of measuring have the greatest efficiency in combination with data of other methods and processing facilities. It is therefore expedient to accumulate in a integrated interface not only the data of measuring but also sets of maps, catalogues of parameters of rocks and tests, chart of experiments, description of methods and matrices (working formats) of processing results. Key moment – they all must be accessible for every certificated specialist of industry, regardless of place of implementation of query. It means that to handle the similar bases of knowledge is reasonable act as thematic portals with the set of maps, algorithms and programs. Examples of such openness of data are both in near (ex-USSR) and in the distant (Western) foreignness. However, in Ukraine there are only a few narrow industry databases given, inaccessible for a wide consumer.

6. An informative crisis attained the Earth sciences, and this requires the systematization and generali-

zation of knowledge. Changing of paradigms within the limits of one-generation make actual a requirement in the remote co-operation between the researchers and industry – for the aims of trade-out of ideas, facilities, skills (symbol mathematics, digital cartography, GIS, numeral optimization, visualization and so on). Such co-operation one can arrange with the help of the creation of *interactive* bases of knowledge based on *open* thematic internet portals, which unite theoretical methods, numeral algorithms, a programs and databases for basic geophysical divisions – from a gravimetry to nuclear geophysics. Creating such bases of knowledge is possible exceptionally based on the common interdisciplinary government program.

The digital databases (maps) of the potential geophysical fields must become the basic filling of such portals. On their basis united by the remote digital technologies the virtual collectives of scientists from different organizations can create the digital models of geological media, both for especially scientific and industrial necessities.

7. An important consequence, following from this generalization, consists of that fact that it is need not simply to abolish the vulture of secrecy, sufficing above gravimetric materials (now it is replaced by a vulture 'Official use only', but to get a concrete gravity source selection did not become easier). It is needed in general to reformulate the concept of intellectual property: to protect by a copyright not the *primary data* of measuring, but the result of their *intellectual treatment*. Thus for result we consider the *scratch data file* of certain program, but not the eventual file of print illustration.

Conclusions and suggestions

A considerable transformation of methodology of processing of high-fidelity gravity data is needed taking into account modern requirements to the precision of interpretation and a modern data about a geoid heights and Earth relief. Adoption of this strategy will be of great **practical value**. In particular,

1. For the reliable prognosis of the dangerous geological and technogenic phenomena, except a theory and programs, one need the array of data of high precision, received from monitoring of geophysical fields on the permanent geophysical grounds. There a separate monitoring links (seismic, magnetic) exist, but they are still without the integrated national center of data. In a gravimetry, similar databases have separate regional character and they are inaccessible for researchers. Because of absence of reconnaissance surveys to begin the creation of digital databases, it's worth by the digitizing and reinterpretation of the archived materials.

2. For this purpose, it is necessary to change cardinally the terms of access to the materials of surveys, and to inculcate within the standard of data origination a new methodology of digitizing of geophysical data. One must do it based on grid-maps of measuring points (data records, but not the isolines). Moreover, one must introduce new methods of reducing of anomalies, and new components of the gravity field into survey planning and preprocessing.

3. A key trends of the geophysics progress are social ones (commercialization, co-operation), technological ones (site building, multi-technique calculations), methodological ones (geo-referencing, guided interpolation, typification of models). They require the creation of the open access knowledge banks and databases. The scientific results received (analytical methods, digital models and databases, illustrations) it is expedient to give in open access – for a scientific association and self-teaching of analysts and students.

4. An existent competition in the access to the *primary data* of the geophysical measuring is deeply vicious; it is expedient only in the distribution of *results* of data interpretation. We suggest revising maintenance of the intellectual property: to declare it not to the *primary data* of surveys (logs of running, matrices of data), but on the results of their *processing* (maps of the field reductions etc.).

5. Change of the methodology of modeling of complicated geophysical processes [9] based on digital databases requires a gradual transformation of the geophysical education in Ukraine, in particular, the development of new courses, teaching forms etc.

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ЗАМІТКИ ЩОДО СТРАТЕГІЇ СТВОРЕННЯ ЦИФРОВИХ БАЗ ДАНИХ ГРАВІМЕТРІЇ В УКРАЇНІ

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Сформульовано адекватні геофізичній практиці вимоги з оптимальності і точності щодо засобів інтерпретації даних потенціальних полів. Вказана необхідність переінтерпретації архівних даних, з метою створення геофізичних баз даних. Вказано, що головною проблемою є створення швидкісних рішень для оцифрування гравіметричних карт.

Узагальнено ряд напрямків, які обґрунтовують нову методологію створення гравіметричних (та інших) баз даних для території України. Запропоновано використовувати як:

- ядро бази даних – СУБД PostgreSQL;
- спосіб оцифрування паперових карт – модифікований спосіб А. Якимчика (вихідна інформація для оцифрування – не карти ізоліній, а журнал пунктів вимірювань;
- новий стандарт первинної обробки гравіметричних даних – адаптований спосіб С. Бичкова.

Рекомендовано додати в комплект карт для інтерпретації карти абсолютних значень поля сили тяжіння; об'єднати у відкритому інтерфейсі взаємодоповнюючі дані по ділянках досліджень. Для забезпечення методології рекомендовано змінити Інструкцію з гравірозвідки від 1980 р. Варто змінити не гриф секретності, а поняття інтелектуальної власності: замінити конкуренцію у доступі до *даних* вимірів конкуренцією *результатів* інтерпретації даних.

Ключові слова: гравіметрія, бази даних, оцифрування карт, переінтерпретація архівних даних, каталог гравіметричних пунктів, абсолютні значення сили тяжіння, новий стандарт.

ЗАМЕЧАНИЯ О СТРАТЕГИИ СОЗДАНИЯ ЦИФРОВЫХ БАЗ ДАННЫХ ГРАВИМЕТРИИ В УКРАИНЕ

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Сформулированы адекватные геофизической практике требования к оптимальности и точности средств интерпретации данных потенциальных полей. Указана необходимость переинтерпретации архивных данных, с целью создания геофизических баз данных. Указано, что главной проблемой является создания скоростных решений для оцифровки гравиметрических карт.

Обобщён ряд направлений, обосновывающих новую методологию создания гравиметрических (и других) баз данных для территории Украины. Предложено использовать в качестве:

- ядра базы данных – СУБД PostgreSQL;
- способа оцифровки бумажных карт – модифицированный способ А. Якимчика (исходная информация для оцифровки не карты изолиний, а журнал пунктов измерений;
- нового стандарта первичной обработки гравиметрических данных – адаптированный способ С. Бычкова.

Рекомендовано добавить в комплект карт для интерпретации карты абсолютных значений поля силы тяжести; объединить в открытом интерфейсе взаимодополняющие данные по участкам исследований. Для обеспечения методологии рекомендовано соответственно изменить Инструкцию по гравиразведке от 1980 г. Следует изменить не гриф секретности, а понятие интеллектуальной собственности: заменить конкуренцию в доступе к *данным* измерений конкуренцией *результатов* интерпретации данных.

Ключевые слова: гравиметрия, базы данных, оцифровка карт, переинтерпретация архивных данных, каталог гравиметрических пунктов, абсолютные значения силы тяжести, новый стандарт.

THE REMARKS ON THE STRATEGY OF THE DIGITAL GRAVITY DATABASES BUILDING IN UKRAINE

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There is postulated a renaissance of gravity surveys due to improvement on the accuracy of measurements and to the development of software for the processing and interpretation of gravimetry data. Adequate requirements to the modern geophysical practice are formulated on the optimal accuracy for the means of interpretation of the potential fields' data. Main trends of reinterpretation of data being stored in the archives are pointed out with the aim of creation a unified digital framework for the geophysical databases. It is denoted that the main problems on this way there are the creation of high-speed solutions for digitization of maps and the creation of digital databases on modern OS platforms.

A series of separate branches are generalized, justifying the creation of a new methodology for gravity (and other) databases for the territory of Ukraine. In particular, we suggest the follow series of improvements:

- As a database engine, one should use a PostgreSQL db management system;
- As a method of paper maps digitizing one should use the modified A. Yakimchik technique (where an input for digitizing is not the *contour maps*, but the *measurements log* (map of the observation points converted into the digital grid map of gravity anomalies); the technique is updated by the open-source analogues of given proprietary software;
- As a new standard of preprocessing of gravity data one should to use the adapted technique of S. Bychkov for counting the layer curvature, relief contribution and indirect effects; one should develop its own parameters for calculating of gravity corrections for the spherical layer impact and other effects on the territory of Ukraine).

We also recommend adding the maps of the absolute values of the gravity field to the standard set of maps for the interpretation. In addition, for this reason we suggest to change the Instructions on gravity surveys of 1980. To ensure the database universality one should combine in a united interface of thematic portal with the public access not only the gravity data but also the complementary data on the area of research. The proper way to do all the strategy of gravity databases building is to change not the secrecy bar on gravity data, but the concept of intellectual property itself: to replace competition within the access to measurements data by the competition on the results of data interpretation.

Key words: gravimetry, databases, maps digitizing, reinterpretation of archive data, catalogue of gravity stations, absolute values of gravity, new standard.